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# Cold-Related Deaths

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## Identification

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### 1. Indicator Description

Unusually cold winter temperatures (e.g., multi-day cold waves) have become less frequent in the United States in recent decades (see the High and Low Temperatures indicator), and studies project that the frequency and intensity of extreme cold waves will decrease as a consequence of climate change and warming temperatures (USGCRP, 2017). When people are exposed to extreme cold, they can suffer from cold-related illnesses, such as frostbite and potentially deadly hypothermia. Thus, as extreme cold events decrease, the risk of cold-related deaths and illness is also expected to decrease (Sarofim et al., 2016). Tracking the rate of reported overall cold-related deaths over time and in conjunction with tracking heat-related deaths provides a measure of how climate change and changing temperatures may affect human well-being.

Components of this indicator include:

- The rate of U.S. annual deaths between 1979 and 2016 for which cold was classified on death certificates as the underlying (direct) cause (Figure 1, orange line).
- The rate of U.S. deaths between 1999 and 2015, for which cold was classified as either the underlying cause or a contributing factor (Figure 1, blue line).

### 2. Revision History

August 2017: Indicator published.

April 2021: Indicator updated with contributing cause of death data through 2015 and underlying cause of death data through 2016.

## Data Sources

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### 3. Data Sources

This indicator is based on data from the U.S. Centers for Disease Control and Prevention's (CDC's) National Vital Statistics System (NVSS), which compiles information from death certificates for nearly every death in the United States. The NVSS is the most comprehensive source of mortality data for the population of the United States. The CDC provided analysis of NVSS data.

### 4. Data Availability

#### *Underlying Causes*

The long-term time series (1979–2016) in Figure 1 is based on CDC's Compressed Mortality File, which can be accessed through the CDC WONDER online database at: <https://wonder.cdc.gov/mortSQL.html>

(CDC, 2018a). CDC WONDER provides free public access to mortality statistics, allowing users to query data for the nation as a whole or by state or region, demographic group (age, sex, race), or International Classification of Diseases (ICD) code. Users can obtain the data for this indicator by accessing CDC WONDER and querying the ICD codes listed in Section 5 for the entire U.S. population.

### *Underlying and Contributing Causes*

The 1999–2015 time series in Figure 1 is based on an analysis conducted by the National Environmental Public Health Tracking (EPHT) Program, which CDC coordinates. CDC staff from the National Center for Environmental Health provided monthly national totals to EPA (CDC, 2018b). This analysis is similar to an analysis that EPHT has published for heat-related deaths at: <https://ephtracking.cdc.gov/DataExplorer>.

Users can query underlying and contributing causes of death through CDC WONDER’s Multiple Causes of Death file (<https://wonder.cdc.gov/mcd-icd10.html>), but note that EPHT performed additional steps for Figure 1 that cannot be recreated through the publicly available data portal (see Section 6).

### *Death Certificates*

Individual-level data (i.e., individual death certificates) are not publicly available due to confidentiality issues.

## **Methodology**

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### **5. Data Collection**

This indicator is based on causes of death as reported on death certificates. A death certificate typically provides space to designate an immediate cause of death along with up to 20 contributing causes, one of which will be identified as the underlying cause of death. The World Health Organization (WHO) defines the underlying cause of death as “the disease or injury which initiated the train of events leading directly to death, or the circumstances of the accident or violence which produced the fatal injury.”

Causes of death are certified by a physician, medical examiner, or coroner, and are classified according to a standard set of codes called the ICD. Deaths for 1979 through 1998 are classified using the Ninth Revision of ICD (ICD-9). Deaths for 1999 and beyond are classified using the Tenth Revision (ICD-10).

Although causes of death rely to some degree on the judgment of the physician, medical examiner, or coroner, the “measurements” for this indicator are expected to be generally reliable based on the medical knowledge required of the “measurer” and the use of a standard classification scheme based on widely accepted scientific definitions. When more than one cause or condition is entered, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications.

Mortality data are collected for the entire population and, therefore, are not subject to sampling design error. For virtually every death that occurs in the United States, a physician, medical examiner, or coroner certifies the causes of death on an official death certificate. State registries collect these death certificates and report causes of death to the NVSS. NVSS’s shared relationships, standards, and procedures form the mechanism by which the CDC collects and disseminates the nation’s official vital statistics.

Standard forms for the collection of data and model procedures for the uniform registration of death events have been developed and recommended for state use through cooperative activities of the states and CDC's National Center for Health Statistics (NCHS). All states collect a minimum data set specified by NCHS, including underlying causes of death and basic demographic data (e.g., age, race, and ethnicity). CDC has published procedures for collecting vital statistics data (CDC, 1995).

This indicator excludes deaths to foreign residents and deaths to U.S. residents who died abroad.

General information regarding data collection procedures can be found in the Model State Vital Statistics Act and Regulations (CDC, 1995). For additional documentation on the CDC WONDER database (EPA's data source for part of this indicator) and its underlying sources, see:

<https://wonder.cdc.gov/wonder/help/cmfm.html>.

CDC has posted a recommended standard certificate of death online at:

[www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf](http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf). For a complete list and description of the ICD codes used to classify causes of death, see: <https://icd.who.int/browse10/2019/en>.

## 6. Indicator Derivation

This indicator reports annual rates of deaths per million population that have been classified with ICD codes related to exposure to natural sources of cold. The NVSS collects data on virtually all deaths that occur in the United States, meaning the data collection mechanism already covers the entire target population. Thus, it was not necessary to extrapolate the results on a spatial or population basis. No attempt has been made to reconstruct trends prior to the onset of comprehensive data collection, and no attempt has been made to project data forward into the future.

### *Underlying Causes*

The long-term trend line in Figure 1 reports the rate of deaths per year for which the underlying cause had one of the following ICD codes:

- ICD-9 code E901: "excessive cold—hypothermia"—specifically subpart E901.0: "due to weather conditions."
- ICD-10 code X31: "exposure to excessive natural cold—hypothermia."

This component of the indicator is reported for the entire year. EPA developed this analysis based on the publicly available data compiled by CDC WONDER. EPA chose to use crude death rates rather than death counts because rates account for changes in total population over time. Population figures are obtained from CDC WONDER.

### *Underlying and Contributing Causes*

The "underlying and contributing causes" trend line in Figure 1 reports the rate of deaths for which either the underlying cause or the contributing causes had one or more of the following ICD codes:

- ICD-10 code X31: "exposure to excessive natural cold—hypothermia."

- ICD-10 code T68: “hypothermia associated with low environmental temperature.” Note that this code is used for contributing causes—never for the underlying cause.
- ICD-10 code T69: “other effects of reduced temperature.” Note that this code is used for contributing causes—never for the underlying cause.

To reduce the chances of including deaths that were incorrectly classified, EPHT did not count the following deaths:

- Any deaths for which the ICD-10 code W93: “exposure to excessive cold of man-made origin,” appears in any cause field. This step removes certain occupational-related deaths—for example, being trapped in a freezer.
- Any deaths for which the ICD-10 code R68.0: “hypothermia, not associated with low environmental temperature,” appears in any cause field. This step excludes certain causes of hypothermia that are not associated with exposure to cold environmental conditions.
- Any deaths for which the ICD-10 code P80: “hypothermia of newborn,” appears in any cause field. This step excludes deaths that may be due to a newborn child’s inability to regulate body temperature.

Foreign residents were excluded. EPHT obtained death counts directly from NVSS, rather than using the processed data available through CDC WONDER. EPHT has not yet applied its methods to data prior to 1999. Crude death rates were calculated in the same manner as with the underlying causes time series.

## 7. Quality Assurance and Quality Control

Vital statistics regulations have been developed to serve as a detailed guide to state and local registration officials who administer the NVSS. These regulations provide specific instructions to protect the integrity and quality of the data collected. This quality assurance information can be found in CDC (1995).

For the “underlying and contributing causes” component of this indicator, extra steps have been taken to remove certain deaths that could potentially reflect a misclassification (see Section 6). These criteria generally excluded only a small number of deaths.

## Analysis

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### 8. Comparability Over Time and Space

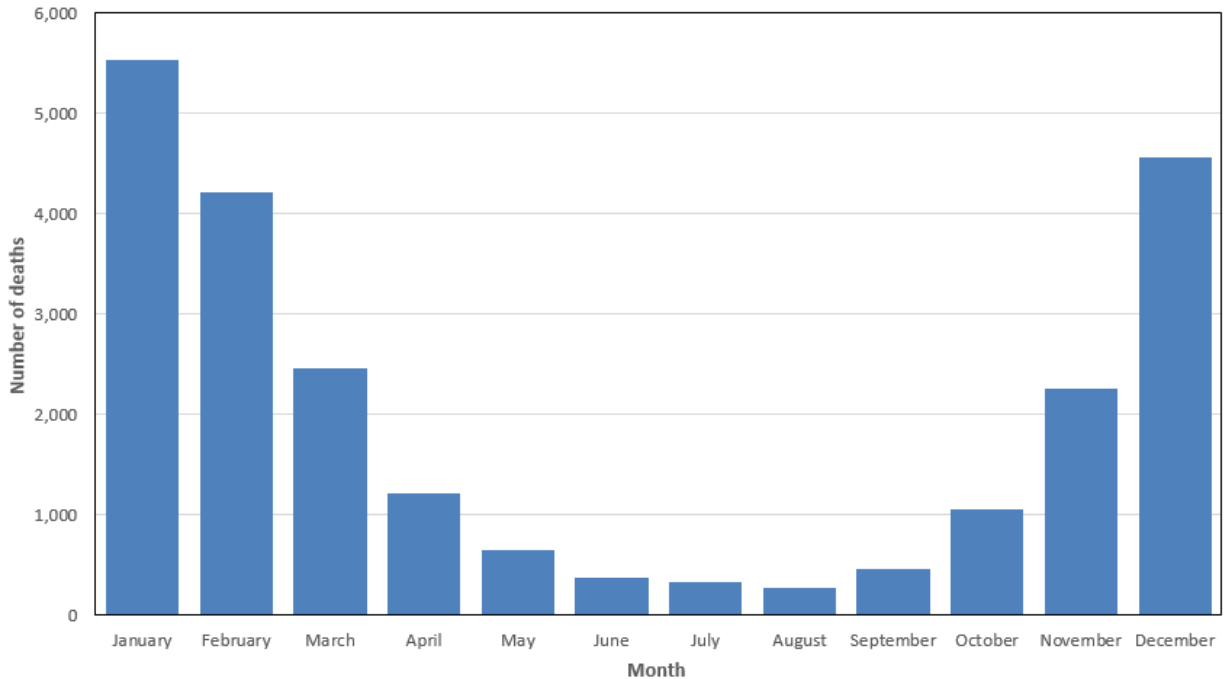
When plotting the long-term data in Figure 1, EPA inserted a break in the line between 1998 and 1999 to reflect the transition from ICD-9 codes to ICD-10 codes. The change in codes makes it difficult to accurately compare pre-1999 data with data from 1999 and later. Otherwise, all methods have been applied consistently over time and space. ICD codes allow physicians and other medical professionals across the country to use a standard scheme for classifying causes of deaths.

## 9. Data Limitations

Factors that may impact the confidence, application, or conclusions drawn from this indicator are as follows:

1. Some deaths associated with cold exposure are not identified as such by the medical examiner and might not be properly coded on the death certificate. In many cases, they might just classify the cause of death as a cardiovascular or respiratory disease, not knowing for certain whether cold was a contributing factor. These causes of death are much more common than cold-related illnesses such as hypothermia. Furthermore, deaths can occur from exposure to more moderately cold temperature (either as an underlying cause or as a contributing factor) that is not classified as extreme and therefore is often not recorded as such. The stress of several cold days can increase one's risk of dying from conditions such as myocardial infarction or cardiac arrest (Medina-Ramon and Schwartz, 2007; Braga et al., 2002), and the effects of cold on the body tend to persist for longer than the effects of heat (Gasparrini et al., 2015), which could make it even more difficult to connect deaths to exposures. Still, this indicator serves as a reportable national measure of overall deaths directly attributable to cold and can be used as evidence for more focused investigations.
2. ICD-9 codes were used to specify underlying cause of death for the years 1979 to 1998. Beginning in 1999, cause of death was specified with ICD-10 codes. The two revisions differ substantially, so data from before 1999 cannot easily be compared with data from 1999 and later.
3. The fact that a death is classified as "cold-related" does not mean that cold temperatures were the only factor that caused the death. Pre-existing medical conditions, certain medications, alcohol or drug use, and other factors can greatly increase an individual's vulnerability to cold. Some deaths classified as "cold-related" reflect human behavior more than weather conditions—for instance, deaths in which alcohol abuse increased a person's susceptibility to cold weather, falling into cold water (which can cause hypothermia, even in the summer), or getting lost on a wilderness excursion. This indicator includes these types of deaths. Nonetheless, deaths classified as "cold-related" are much more common in colder months of the year than in warmer months, as Figure TD-1 shows.
4. Cold weather is not the only factor that can affect trends in "cold-related" deaths. Other factors include the vulnerability of the population and the extent to which people have adapted and acclimated to cold temperatures.

**Figure TD-1. Deaths Classified as “Cold-Related” in the United States by Month, 1999–2015**



*This graph shows all deaths for which cold was recorded as either the underlying cause or a contributing cause of death, which corresponds with the blue line in Figure 1 of this indicator. Deaths have been aggregated by month over the entire period of record.*

Data source: CDC, 2018b

## 10. Sources of Uncertainty

Uncertainty estimates are not available for this indicator. Because statistics have been gathered from virtually the entire target population (i.e., all deaths in a given year), these data are not subject to the same kinds of errors and uncertainties that would be inherent in a probabilistic survey or other type of representative sampling program.

Some uncertainty could be introduced as a result of the professional judgment required of the medical professionals filling out the death certificates, which could potentially result in misclassification or underreporting in some number of cases.

## 11. Sources of Variability

There is substantial year-to-year variability within the data. Further study is needed to determine the extent to which year-to-year variations in cold-related deaths might reflect general weather conditions (e.g., a particularly cold winter in a certain region), the status of winter illness in the population (e.g., a particularly bad strain of influenza), or specific extreme cold events.

## 12. Statistical/Trend Analysis

This indicator does not report on the slope of the apparent trends in cold-related deaths, nor does it calculate the statistical significance of these trends.

### References

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